NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Up to Wind Speed

Up to Wind Speed — October 2012

Up to Wind Speed is a quarterly newsletter from the U.S. Department of Energy's (DOE's) National Wind Technology Center (NTWC) at the National Renewable Energy Laboratory (NREL).

For more than three decades, research conducted by NREL's Wind Program has helped industry advance wind energy technology, increasing reliability and lowering the cost of energy. Each quarter, the newsletter keeps you up to speed on what's happening in wind energy research and development and provides you with links to the NWTC's recent publications.

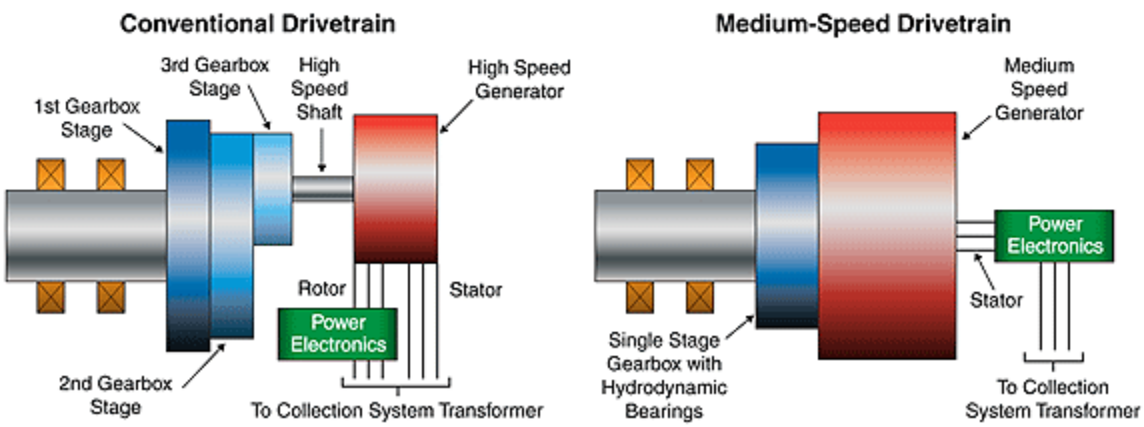
In this issue:

New Drivetrain Design Loses Tons of Excess Weight and Reduces Costs

Building on its role as a world-class DOE research facility, NREL and its industry partners (BEW Engineering, Brad Foote Gear Works, Clipper Windpower, CREE, Danotek Motion Technologies, McCleer Power, DOE's Oak Ridge National Laboratory, QuesTek, Romax Technology, Texas Tech University, and Vestas) have developed an innovative drivetrain system designed to increase reliability, decrease mass, improve efficiency, and reduce costs. In addition, NREL's medium-speed drivetrain will facilitate the scaling of generator design up to ratings as high as 10 megawatts (MW) while achieving reductions in installed capital cost and levelized cost of energy.

NREL's new design takes a system approach to improving the conventional wind turbine drivetrain design by focusing on all three of its major drivetrain systems: a single-stage gearbox, a medium-speed permanent-magnet generator, and high-efficiency power electronics. Traditional three-stage high-speed gearbox designs have been plagued with reliability issues caused by the large and unpredictable loads imparted on the gears and bearings from the wind acting on the rotor. The NREL design eliminates the last two stages of the traditional gearbox (the lower-reliability, higher-speed stages); uses a more compliant gear system of flex-pins and journal bearings in the remaining low-speed planetary stage that improves load distribution and increases the overall reliability; and is constructed from premium steels, which increases capacity. This single-stage gearbox connects to a medium-speed generator. When scaled up to 10 MW, the system will weigh several hundred tons less than a conventional direct-drive system of similar power and will use a fraction of the rare-earth magnets.

Additionally, the generator operates at medium voltage (3,300 Volts), rather than the traditional low-voltage designs, which reduces cooling system requirements and the copper mass and cost of the power cables running down the tower. Efficiency improvements in the power electronics are derived from advanced materials and improved circuit design. These combined innovations result in increased reliability, capacity, and efficiency; and thus, more energy generation and a lower cost of energy.



This illustration compares a medium-speed drivetrain to a conventional drivetrain. NREL's medium-speed drivetrain is designed to increase reliability, improve efficiency, and reduce costs.

AWEA Releases Long-Awaited Offshore Wind Consensus Document

The American Wind Energy Association (AWEA) released its long-awaited consensus document, AWEA Offshore Compliance Recommended Practices 2012 (OCRP 2012), at its Offshore WINDPOWER Conference, in October, in Virginia Beach.

Developed in collaboration with the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), AWEA's OCRP 2012 recommends good practices in the use of existing standards for planning, designing, constructing, and operating offshore wind facilities.

Efforts to develop the recommended practices document began in 2009 when industry and regulatory agencies raised concerns over the lack of a single set of standards or guidelines for offshore wind development in the United States. The development of the guidelines is critical to industry because they will lead to mature standards that will reduce uncertainty and project risk and ultimately help lower the cost of offshore wind energy. These recommended practices leverage multiple standards already in use in Europe but also compile many other standards from other industries to address the unique conditions in U.S. coastal waters.

To develop the U.S. guidelines, AWEA and NREL enlisted the help of more than 50 offshore wind industry experts to identify the best practices using four levels of existing standards: international standards, national standards (e.g., the American Petroleum Institute), classification society standards (e.g., Germanischer Lloyd, Det Norske Veritas, and The American Bureau of Shipping), and commercial standards and guidelines. The resulting OCRP 2012 addresses five critical areas in the development of an offshore wind facility:

- Structural reliability
- Manufacturing, qualification testing, installation, and construction
- Safety of equipment
- Operation and inspection
- Decommissioning.

The process used to develop AWEA's OCRP 2012 followed the AWEA Standards Development Procedures that were adopted by AWEA in 2007. AWEA is the Accredited Standards Developer under the authority of the American National Standards Institute for consensus wind energy standards in the United States.

Great Minds Join Forces at the Inaugural Meeting of the North American Wind Energy Academy

The North American Wind Energy Academy (NAWEA) held its inaugural meeting August 7-9, 2012, at the University of Massachusetts Amherst. Sponsored by DOE, the meeting drew 92 participants from 17 states and Canada, including 22 universities, eight commercial companies, and four government laboratories.

NAWEA members are a diverse blend of academic, laboratory, and industry leaders working toward a common goal. Several of the signatories of the agreement (pictured here) gathered after the signing ceremony to support the development of the academy.

Robert Thresher, research fellow at NREL, was selected as the inaugural director to lead the establishment of NAWEA as a working institution in North America.

The newly formed NAWEA connects research institutions, universities, and industry professionals with the combined vision that wind power can achieve a greater contribution to the electricity needs of the continent. To achieve this vision, it is necessary to dramatically reduce cost while exceeding current levels of service and performance. NAWEA's mission is to facilitate the formation of high-quality, national scientific research collaborations to address high-risk, multidisciplinary, multi-institutional research challenges that present barriers to the wide-spread use and high penetration of wind energy in North America. In addition, NAWEA will enhance opportunities for the education and training of the needed skilled workforce at all levels, but with a special focus on graduate-level research. NAWEA members agreed to collaborate and share their knowledge, skills, and capabilities to promote education in wind energy technologies. Visit NAWEA's website for more information.

NWTC Researchers Gain Valuable Data from Floating Offshore Wind Prototype

DOE's National Wind Technology Center at NREL is collaborating with SWAY, a renewable energy company in Norway, on an offshore wind energy demonstration project deployed off the coast of Bergen, Norway. The project provides NWTC researchers with a unique opportunity to study one of the world's first floating wind turbines to be deployed and will enhance SWAY's data collection program. SWAY hopes these data will validate its design for a 10-MW floating offshore wind turbine.

SWAY's one-fifth-scale prototype demonstration wind energy system installed off the coast of Bergen, Norway.
NREL/PIX 21966

The SWAY one-fifth-scale prototype has a 13-m downwind rotor on a 29-m tower, with a large portion of the tower beneath the ocean surface. The tower and turbine rotate together on the mooring and are designed to swivel according to wind direction. A downwind rotor allows the tower to have support cables on the upwind side, reducing the structural requirements on the tower and saving weight and costs.

The NWTC sent members of its staff to the deployment site in June to install scientific equipment on the seabed and on the prototype above the water line to collect data that will help validate a computer model of the SWAY design. Installing the equipment has provided NWTC researchers with practical experience on testing floating offshore wind systems, and the data gathered from this project will accelerate the development of offshore wind design tools and models.

The instruments on the seabed will collect information such as wave height and direction, tidal variations, and sea temperatures. Instrumentation installed on the prototype above the water will collect atmospheric data such as wind speed and direction and operational data such as platform motions, loads, and performance.

Since its commissioning on June 23, 2012, the equipment has been collecting data around the clock at a rate of 1.5 gigabytes per day. NWTC researchers hope to continue collecting data for 6 months to a year. The researchers will then remove the equipment, analyze the data, and publish a report on their findings.

WTTC Earns A2LA Multimegawatt Blade Testing Status

The Massachusetts Wind Technology Testing Center (WTTC), a joint effort by DOE, the Massachusetts Clean Energy Center, and NREL, was recently accredited by the American Association for Laboratory Accreditation (A2LA) to test wind turbine blades to International Electrotechnical Commission (IEC) standards. The facility is one of the first test centers in the world that can test blades up to 90 meters (m) in length, and is the only test facility in the United States that is accredited to test these longer blades to IEC standards.

Manufacturers that have their blades tested by an accredited center can use the test results to have their blades certified, and certification plays a critical role in successful marketing at home and abroad. Local building authorities, project financiers, and insurance companies ask for certification to reduce their risk before projects move

The Wind Technology Test Center in Boston, Massachusetts, is the only test center in the United States capable of testing wind turbine blades up to 90 m in length to IEC standards. Here, the test center is preparing two 49-m blades for testing. The blade on the left is being prepared for a flapwise static test and the blade on the right for an edgewise fatigue test.
Source: Nathan Post, WTTC

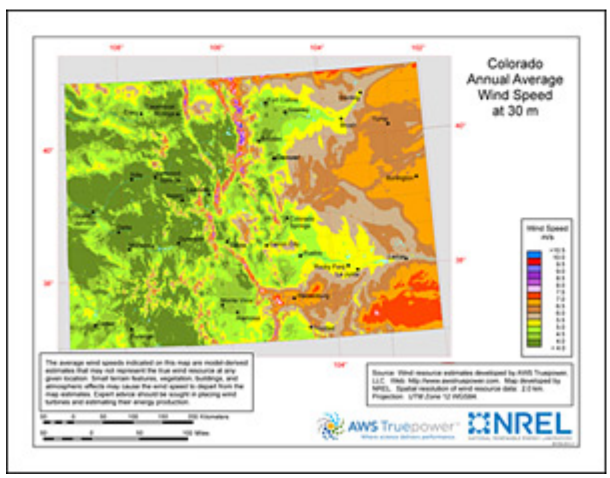
forward. To compete overseas, U.S. manufacturers must have their products certified to standards adopted by other nations.

In certification, an independent party gives written assurance that a product, process, or service conforms to specified requirements. International certification relies on standards that are continually updated and expanded. This standards development process is conducted by international committees of experts, the foremost being the IEC, to develop appropriate international standards and testing procedures. Researchers in DOE's Wind Program work closely with the IEC to ensure reciprocity and acceptance of the U.S.-developed analytic tools used in the process of designing wind turbines and wind turbine components.

Researchers from the NWTC at NREL and the Massachusetts Clean Energy Center have worked together for the past year to develop and implement the quality management system required to achieve accreditation. By the end of September 2012, the WTTC had completed certification testing on several multimegawatt blades for industry partners.

Getting a Closer Look with 30-m Wind Resource Maps

For many businesses, location is everything—and this is especially true for the wind business. From utility-scale wind farms to individual community turbines, developers need to know where the best wind resources are located. To find high-resolution maps of annual average wind resources at heights of 50, 80, and 90 meters (m), large-scale developers can visit DOE's Wind Powering America website. Now small-scale wind turbine developers have access to national- and state-level maps at a height that is specific to their needs: 30 meters.



On the Wind Powering America website, developers can access 30-m wind resource maps at the national and state levels (the 30-m map for the state of Colorado map is shown here).

The first comprehensive small wind resource map of its kind, the 30-m map was developed by NREL and AWS Truepower. The map's objective is to provide a much-needed bird's-eye view of the potential wind resource in a designated area for project prospecting purposes.

Anyone interested in small-scale wind development can access the maps they need, including policy makers, stakeholders, consumers, dealers and manufacturers, utilities and renewables programs, site assessors, homeowners, and so on.

The new 30-m maps:

- Are based on the same numerical weather prediction models used for the utility-scale maps
- Help inform the wind analysis processes of wind turbine deployment
- Use a multitude of data inputs, such as elevation, slope, land cover, vegetation, ground cover, albedo (reflectivity), and moisture, to name a few
- Provide a long-term annual average (at least 15 years) to help inform the potential costs, energy production, and sustainability over the course of a project's lifecycle.

Because each prospective wind site can be distinctively unique due to local effects on the wind (including vegetation, buildings, small terrain features, and so on), the average wind speeds indicated on the map may not represent the true annual average wind resource. As a result, it is recommended that consumers use the wind resource maps as a starting point and consult with qualified professionals where appropriate.

In the future, the 30-m wind maps may be completed with additional information, such as the prevailing wind directions and seasonal variability of the wind resource, which can be useful to further understand an area's wind characteristics.

To access the 30-, 50-, 80-, and 90-meter wind resource maps, visit the Wind Powering America website and click on the Land-Based and Offshore Wind Maps image. Or, for more detailed information on the overall wind resource map history, underlying methodology, development, and appropriate usage, visit the 30-Meter Height Resolution Wind Map for Small and Distributed projects page for a free 1-hour webinar.

Podcasts Showcase Progress in Greensburg

Greensburg, Kansas, is a town in transition. On May 4, 2007, a tornado tore through the small town, leaving behind a wake of devastation. But the citizens of Greensburg did not give up, and 5 years later, the town is a prime example of what it means to persevere, rebuild, and renew.

Wind—the same element that almost destroyed Greensburg—is now one of the town's premier

With help from NREL, Greensburg is becoming greener by generating electricity through the use of renewable energy technologies. As part of an ongoing initiative, NREL's Wind Powering America (WPA) team works with the National Association of Farm Broadcasters (NAFB) to conduct radio interviews highlighting wind energy-related topics, such as Greensburg's progress. The NAFB then broadcasts the interviews to rural radio stations, and WPA provides the interviews as podcasts on its website. As part of an outreach effort from WPA and NREL, the podcasts are intended to provide rural stakeholders with helpful information on wind energy and recommendations on how to best use the resource.

sources of renewable energy. Shown here is the Greensburg Wind Farm, comprised of ten 1.25-megawatt (MW) wind turbines that supply 12.5 MW of wind power.
NREL PIX 17592

The most recent Greensburg podcasts focus on the following:

- **Five years after the tornado**. Bob Dixson, the mayor of Greensburg, shares the reasoning behind the town's decision to rebuild using renewable energy technologies, specifically wind energy.
- **The benefits of using wind power at a local hotel**. Ron Wright, owner of the Best Western Inn in Greensburg, discusses his process for adopting wind energy and the benefits of installing a 100-foot wind turbine at his hotel.
- **Supplementing grid power with wind-generated power at the new community hospital**. Mary Sweet, administrator at the Kiowa County Memorial Hospital, talks about the hospital's ambitious plan for rebuilding and how their new wind turbine is literally paying off.

The final interview in the Greensburg series will describe how wind energy now powers schools in the area. You can download it and more podcasts from the WPA website.

An on-site wind turbine generates approximately 220,000 kilowatt-hours of electricity annually at the new Kiowa County Memorial Hospital.
Photo by Dennis Schroeder, NREL PIX 20006

Recent NREL Wind Publications

- 2011 Wind Technologies Market Report
- Analyzing the Deployment of Large Amounts of Offshore Wind to Design an Offshore Transmission Grid in the United States: Preprint
- Combined Effects of Gravity, Bending Moment, Bearing Clearance, and Input Torque on Wind Turbine Planetary Gear Load Sharing: Preprint
- Comparison of Two Independent LIDAR-Based Pitch Control Designs
- Comparison of Wind Power and Load Forecasting Error Distributions: Preprint
- Data Clustering Reveals Climate Impacts on Local Wind Phenomena
- Economic Evaluation of Short-Term Wind Power Forecasts in ERCOT: Preliminary Results; Preprint
- Enhanced Short-Term Wind Power Forecasting and Value to Grid Operations: Preprint
- Examining the Variability of Wind Power Output in the Regulation Time Frame: Preprint
- The Impact of Wind Development on County-Level Income and Employment: A Review of Methods and an Empirical Analysis
- Impacts of Wind and Solar on Fossil-Fueled Generators: Preprint
- Integrating Wind and Solar Energy in the U.S. Bulk Power System: Lessons from Regional Integration Studies
- Investigating the Influence of the Added Mass Effect to Marine Hydrokinetic Horizontal-Axis Turbines Using a General Dynamic Wake Wind Turbine Code
- Large-Eddy Simulation Study of Wake Propagation and Power Production in an Array of Tidal-Current Turbines: Preprint
- LIDAR Wind Speed Measurements of Evolving Wind Fields
- Markets to Facilitate Wind and Solar Energy Integration in the Bulk Power Supply: An IEA Task 25 Collaboration
- Offshore Wind Plant Balance-of-Station Cost Drivers and Sensitivities (Poster)
- Operational-Condition-Independent Criteria Dedicated to Monitoring Wind Turbine Generators: Preprint
- The Past and Future Cost of Wind Energy: Preprint

- Probabilistic Approach to Quantifying the Contribution of Variable Generation and Transmission to System Reliability: Preprint
- Renewable Electricity Futures (Presentation)
- Seismic Loading for FAST: May 2011 – August 2011
- Solar Reserve Methodology for Renewable Energy Integration Studies Based on Sub-Hourly Variability Analysis: Preprint
- Stochastic Methods for Planning and Operating Power Systems with Large Amounts of Wind and Solar Power: Preprint
- U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis
- Understanding Inertial and Frequency Response of Wind Power Plants: Preprint
- The Value of Geographic Diversity of Wind and Solar: Stochastic Geometry Approach
- Western Wind and Solar Integration Study Phase 2: Preprint
- Wind Power Forecasting Error Distributions: An International Comparison: Preprint
- Wind Power Forecasting Error Frequency Analyses for Operational Power System Studies: Preprint
- Wind Power Opportunities in St. Thomas, USVI: A Site-Specific Evaluation and Analysis
- Wind Power Plant Prediction by Using Neural Networks: Preprint
- Wind Powering America (Postcard)
- Wind Powering America Newsletter (Postcard)
- Wind Turbine Gearbox Condition Monitoring Round Robin Study — Vibration Analysis